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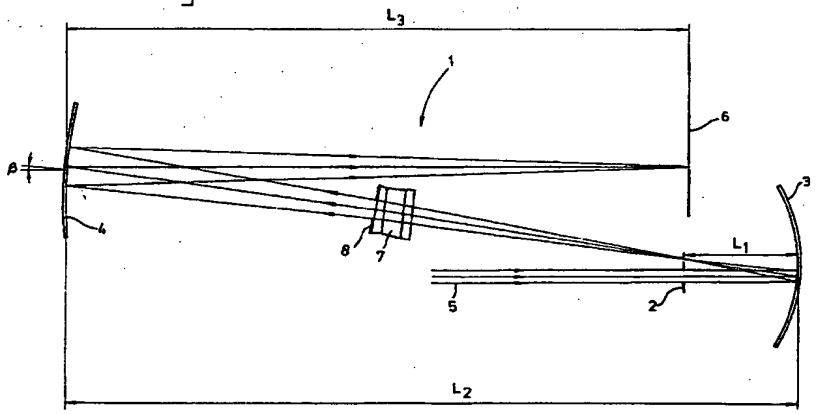
(54) Telescope with a large field of vision

(57) Telescope comprising two or more reflecting elements (3,4), wherein a light beam impinging on a first reflecting element (3) leaves through a second reflecting element (4), in which the shape of the reflecting surface of the second reflecting element is concave. The shape of the reflecting surface of the first reflecting element is concave. An entrance pupil (2) is arranged in the light path in front of the first reflecting element (3) and the first reflecting element (3) images the entrance pupil (2) nearly in the focus of the second reflecting element (4).

fig-1



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Description

The invention relates to a telescope comprising two or more reflecting elements, in which a light beam impinging on a first reflecting element leaves through a second reflecting element, in which the shape of the reflecting surface of the second reflecting element is concave.

Such a telescope could be placed in practice for example in front of an imaging spectrometer for imaging an object at its entrance slot. The combination of imaging spectrometer and telescope could be provided for example in a satellite or an aeroplane and could be used for example for chartering or monitoring the ozone layer.

A telescope of the type mentioned at the beginning is known from DE-A-3614639. The known telescope consists of a first convex and a second concave mirror and has advantageous relatively small dimensions. However, the known telescope has the disadvantage that its field of vision is limited. In the above mentioned application this results for example in a satellite, which must revolve many times around the earth for covering a predetermined area of the ozone layer.

This invention has the object to provide a telescope of the type mentioned above having comparable dimensions but having a larger field of vision.

The telescope according to this invention is therefore characterized in that the shape of the reflecting surface of the first reflecting element is concave, that an entrance pupil is located in the light path in front of the first reflecting element and that the first reflecting element images the entrance pupil approximately in the focus of the second reflecting element.

Moreover, the telescope according to the invention has the advantage that the light beam impinging on the telescope leaves nearly parallel to each other. Therefore, the outgoing light beams will impinge nearly perpendicular to the entrance slot of a spectrometer located in use behind the telescope. Consequently, the telescope according to the invention is suitable for using it in nearly all of the known spectrometers. Because of said nearly perpendicular incidence of the light beams the telescope according to the invention may also be used in combination with a spectrometer having small dimensions. Thereby no additional elements are required for diminishing the angle of incidence of such a spectrometer. The possibility of using a small spectrometer is particularly advantageous in the above mentioned implementation because of the small available space in a satellite or aeroplane.

This invention will be described in more details by reference to the accompanying drawings, in which

Figure 1 shows a side view of a preferable embodiment of the telescope according to the invention;
Figure 2 shows a plane view of the preferable embodiment of Figure 1.

In both of the figures similar elements are indicated by equal reference numbers.

Figure 1 shows a side view of a preferable embodiment of the telescope according to the invention. In the shown embodiment the telescope 1 comprises an entrance pupil 2, a first reflecting element 3 and a second reflecting element 4. The shape of the reflecting surface of the reflecting elements 3 and 4 is concave. A light beam 5 impinging on the telescope passes successively the entrance pupil 2, the first reflecting element 3 and the second reflecting element 4. The construction of the telescope 1 is such that the first reflecting element 3 images the entrance pupil 2 approximately in the focus of the second reflecting element 4. This has the advantage that all of the impinging light beams leave the telescope nearly parallel to each other. The outgoing light beams 5 impinge thus also nearly perpendicular on a spectrometer located in use after the telescope, of which only the entrance slot 6 is shown. This facilitates the use of the telescope according to the invention in combination with a spectrometer having small dimensions. By said nearly perpendicular incidence of the light beams on such a spectrometer also a sufficient image of the object to be tested could be formed at the entrance slot of a relatively small spectrometer after all. Furthermore, the telescope 1 provides an image of the object on the spectrometer in a nearly straight image plane in contrast to the known telescope resulting in a curved image plane. In view of the above mentioned description it will be clear that the telescope according to the invention is suitable for using it in combination with practically all known imaging spectrometers.

Figure 2 shows a plane view of the preferable embodiment of Figure 1. The angle α is a measure for the field of vision of the telescope 1. In the shown embodiment the telescope 1 has an angle $\alpha \geq 90$ degrees. In contrast $\alpha \leq 30$ degrees is valid for the known telescope. The telescope according to the invention results thus in a substantial improvement in field of vision in comparison to the known telescope. With the shown preferable embodiment the telescope according to the invention has, just like the known telescope, in addition the advantage of relatively smaller dimensions, which will be explained later.

In the known preferable embodiment the reflecting elements 3 and 4 are mirrors. The reflecting surface of the mirrors may be both spherical and aspherical in shape. Because of its simple manufacturing the use of mirrors with spherical surfaces is preferred. It will be clear for one skilled in the art that dependent on the aimed application many kinds of materials are suited for the reflecting surfaces. Examples of suitable materials are aluminum, optical glass types and materials with a partly amorph and a partly crystalline structure such as Zerodur®. Preferable both of the mirrors have an angle of inclination β approximately lying between 0 and 25 degrees. In the known preferred embodiment the radius of curvature of the mirror 3 is nearly 60.3 mm. The radius of curvature of mirror 4 is nearly 195 mm. In order

to minimize light scattering the reflecting surfaces of the mirrors 3 and 4 are preferably polished.

Entrance pupil 2 may comprise all kinds of light absorbing materials. The entrance pupil has preferably an electrical opening of approximately 6.4 mm by 3.3 mm. In the shown embodiment the entrance pupil is positioned horizontally with the long axis seen in the plane of Figure 2.

In the shown preferable embodiment the entrance pupil 2 is located at a distance l1 of approximately 37 mm as to mirror 3. Mirrors 3 and 4 are spaced at a mutual distance l2 of approximately 230 mm. Mirror 4 is arranged at a distance l3 of nearly 190.4 mm from the entrance slot 6 of the spectrometer. For a good operation of the telescope 1 an accuracy of at least 1% and more preferably 0.2% is preferably valid for all of the distances and radii of curvature.

It is self-evident that the mentioned dimensions are only illustrative and are by no means meant to limit the invention. The dimensions illustrate indeed the handy size of the preferred embodiment of the telescope according to the invention. This handy size is substantially advantageous, in particular in locating the telescope in a satellite or aeroplane, such as in the above described application in an Ozone Monitoring Instrument. The mentioned dimensions indicate further only in proportions the mutual distances and sizes of the components in the shown configuration. If desired the whole configuration could be upscaled by a predetermined factor. Thereby the large field of vision is maintained.

Optionally a depolarisator 7 could be inserted in the light path between mirrors 3 and 4. In this way the telescope according to the invention is favourably made polarisation independent. This is also true for any instrument located thereafter, such as the spectrometer. Depolarisator 7 is built up preferably in a known way from four wedges from quartz crystal.

Moreover, a diaphragm 8 may be arranged behind depolarisator 7 for optimizing the operation of the telescope further. Preferably, diaphragm 8 is located nearly in the focus of the second mirror 4. The opening of the diaphragm 8 is preferably smaller than the image of the entrance pupil 2 at the location of the diaphragm. The quantity of scattering light is minimized by means of diaphragm 8. In addition the diaphragm serves that the transmitted quantity of light for all of the angles of vision are nearly equal. Diaphragm 8 is preferably manufactured from light absorbing material.

Without any doubt many embodiments and modifications of the described telescope will appear to those skilled in the art. The telescope according to the invention may be implemented for example with lenses instead of mirrors. The use of lenses, however, has the disadvantage that so called "colour errors" will occur. This means among others that it is difficult feasible with lenses to image light of different wavelengths with an equal spot size.

The telescope according to the invention is naturally not limited to the described and illustrated embodiment, but comprises any embodiment being consistent with the above description and the enclosed drawings and being with the scope of the enclosed claims.

Claims

1. Telescope comprising two or more reflecting elements, in which a light beam impinging on a first reflecting element leaves through a second reflecting element, in which the shape of the reflecting surface of the second reflecting element is concave, **characterized in** that the shape of the reflecting surface of the first reflecting element is concave, that an entrance pupil is located in the light path in front of the first reflecting element and that the first reflecting element images the entrance pupil substantially in the focus of the second reflecting element.

2. Telescope according to claim 1, wherein the angle of inclination of the reflecting elements lies approximately between 0 and 25 degrees.

3. Telescope according to one of the preceding claims, wherein the radius of curvature of the reflecting surface of the first reflecting element is nearly 60.3 mm, the radius of curvature of the reflecting surface of the second reflecting element is nearly 195 mm, the distance between the entrance pupil and the first reflecting element is nearly 37 mm and the distance between the first and the second reflecting element is nearly 230 mm.

4. Telescope according to one of the preceding claims, wherein a depolarisator is located in the light path between the first and the second reflecting element.

5. Telescope according to one of the preceding claims, wherein a diaphragm is arranged in the light path between the first and the second reflecting element nearly in the focus of the second reflecting element.

6. Telescope according to claim 5, wherein the opening of the diaphragm is substantially smaller than the image of the entrance pupil at the location of the diaphragm.

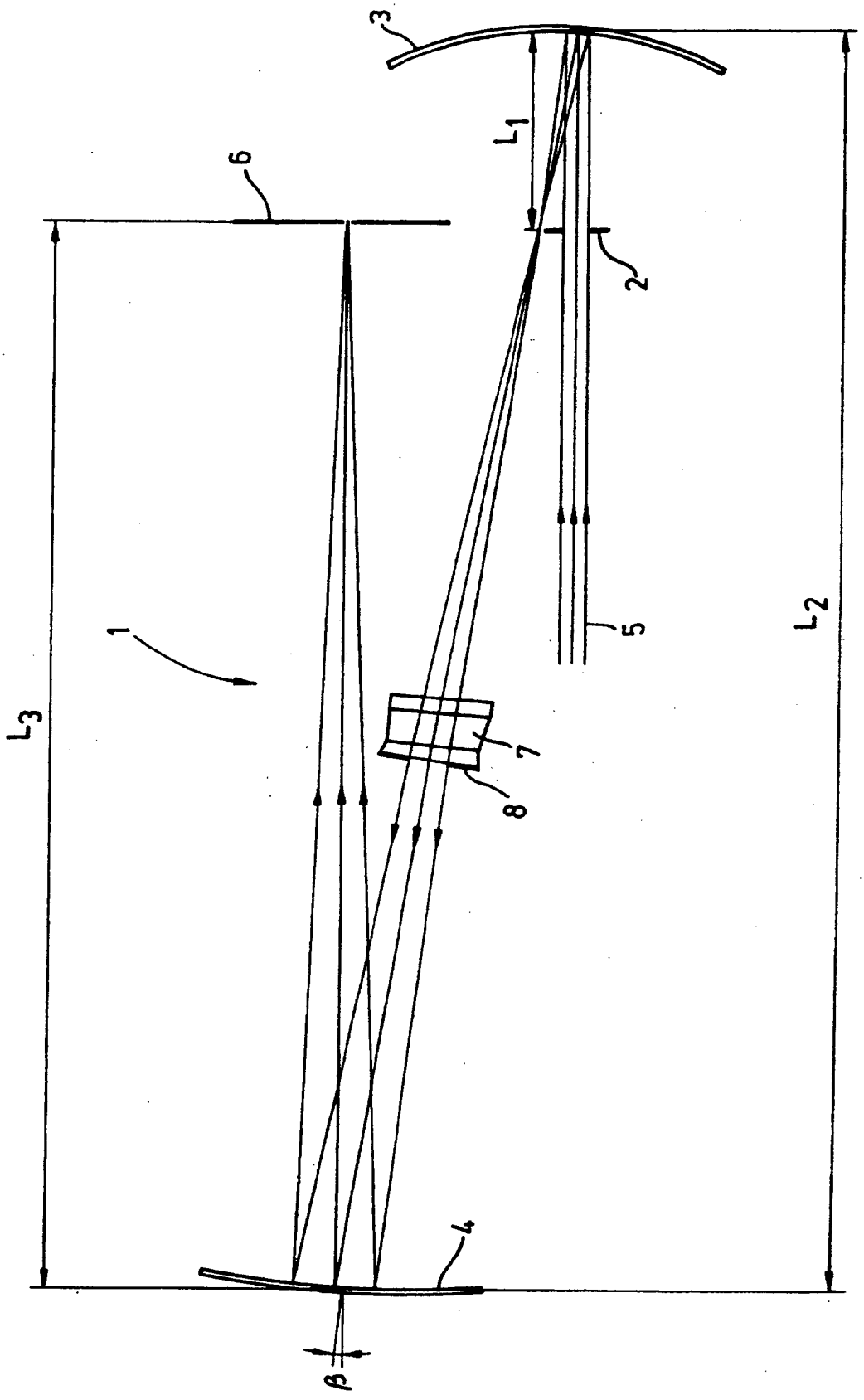

fig-1

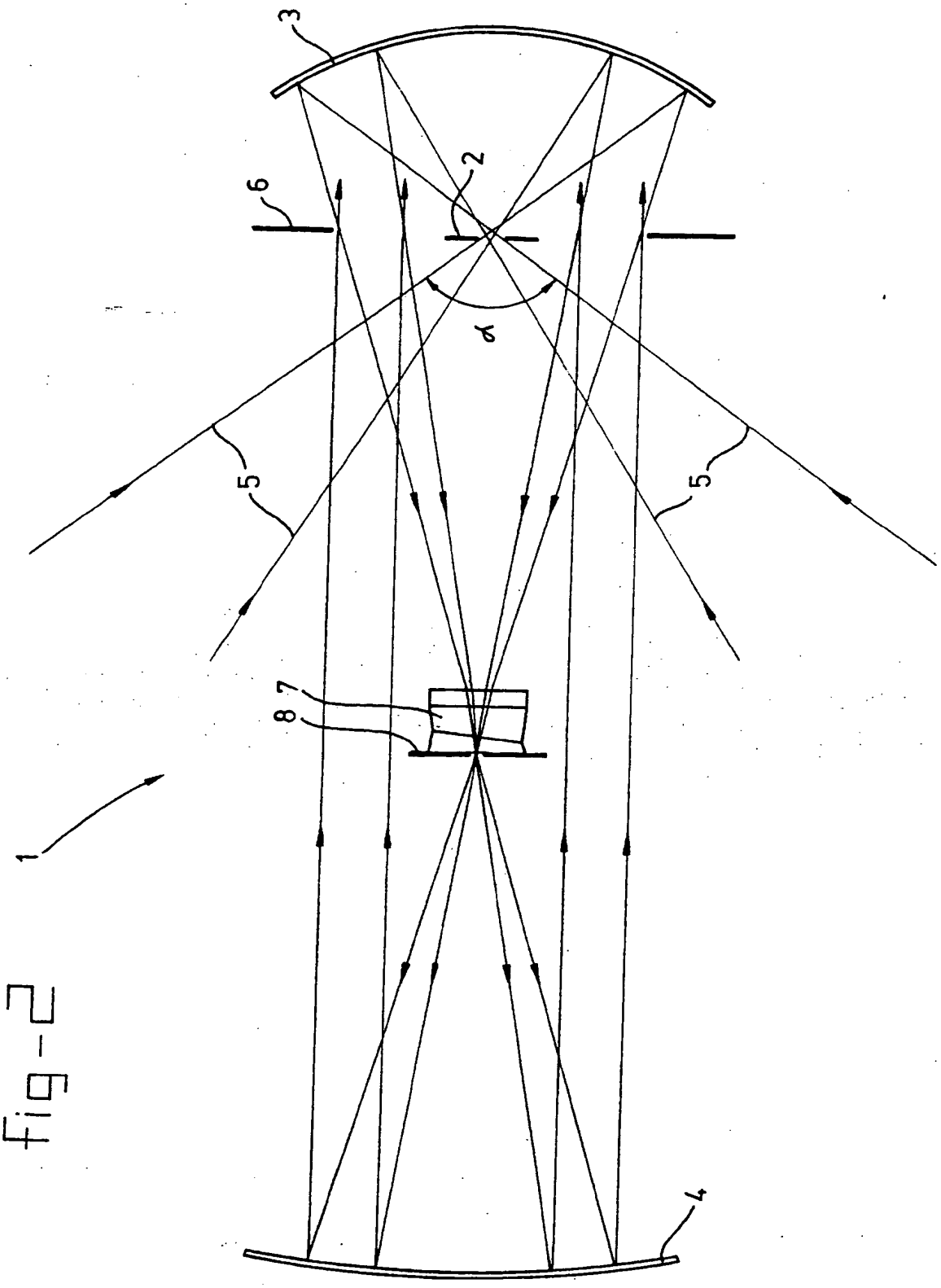

Fig-2

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EUROPEAN SEARCH REPORT

Application Number
EP 96 20 3631

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	APPLIED OPTICS, vol. 32, no. 10, 1 April 1993, pages 1768-1774, XP000356623 BOTTEMA M: "REFLECTIVE CORRECTORS FOR THE HUBBLE SPACE TELESCOPE AXIAL INSTRUMENTS" * figure 5 * ---	1,2	G01J3/28 G02B17/06
A	EP 0 129 289 A (PHILIPS ELECTRONIC ASSOCIATED ;PHILIPS NV (NL)) 27 December 1984 * the whole document * ---	1,2	
A	OPTICAL ENGINEERING, vol. 33, no. 1, 1 January 1994, pages 116-124, XP000421274 STAVROUDIS O N: "SCHIEFSPIEGLER: AN OFF-AXIS REFLECTING OPTICAL SYSTEM" * figures 1,3 * ---	1,2	
D,A	US 4 773 756 A (BLECHINGER FRITZ) 27 September 1988 * the whole document * -----	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

G01J
G02B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	20 March 1997	Scheu, M

CATEGORY OF CITED DOCUMENTS

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